Overview RUN6—Injectors

Haixin Huang

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RHIC retreat

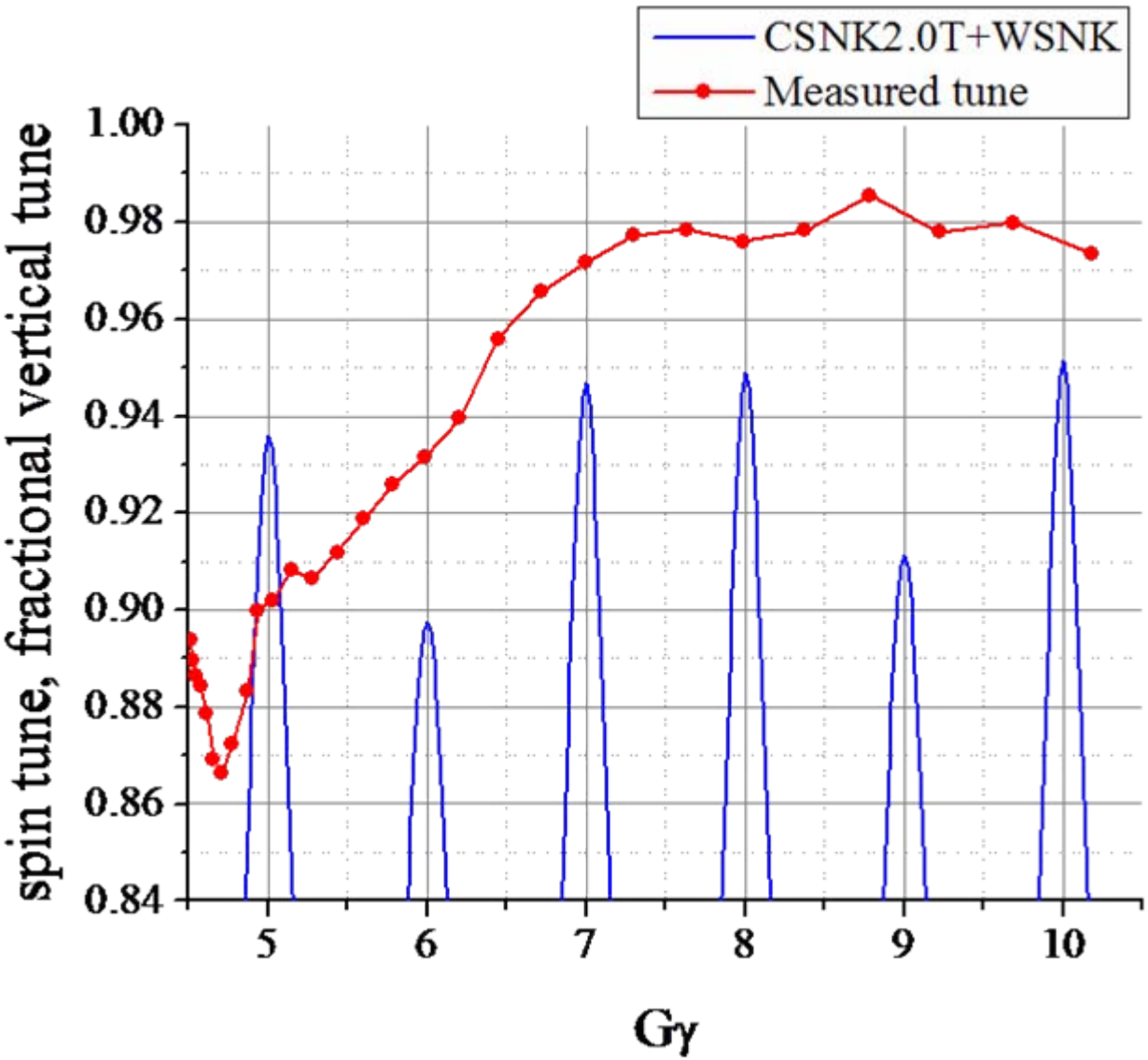
BROOKHAVEN
NATIONAL LABORATORY

Challenge of the Setup

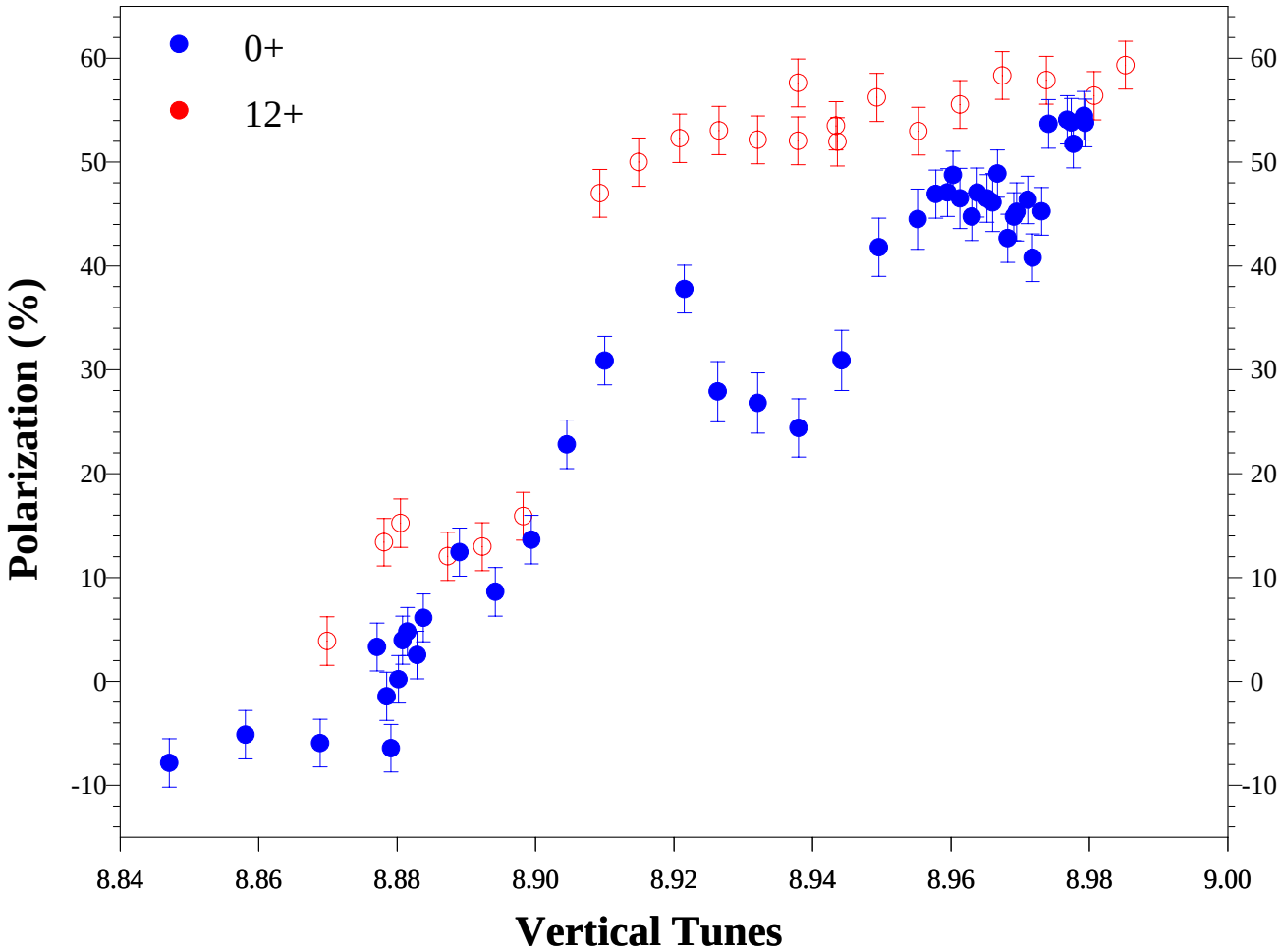
- The horizontal resonance effect is measurable over the whole ramp. The following snake setup gave the best polarization: 10% cold snake, 5.9% warm snake.
- With two helical magnets installed, the lattice is largely distorted at low energies. It took quite a lot efforts to set the vertical tune close to integer. Vertical tune is higher than 8.98 at all major intrinsic resonances. It is even as high as 8.994 at $36+\nu$.
- Even with such strong partial snakes, 9^{th} harmonics at $36+\nu$ could still cause polarization loss with certain orbit distortion amplitude.
- RHIC injection energy was lowered by 1 unit of $G\gamma$ for better spin transmission.

Spin Tune and Fractional Vertical Tune

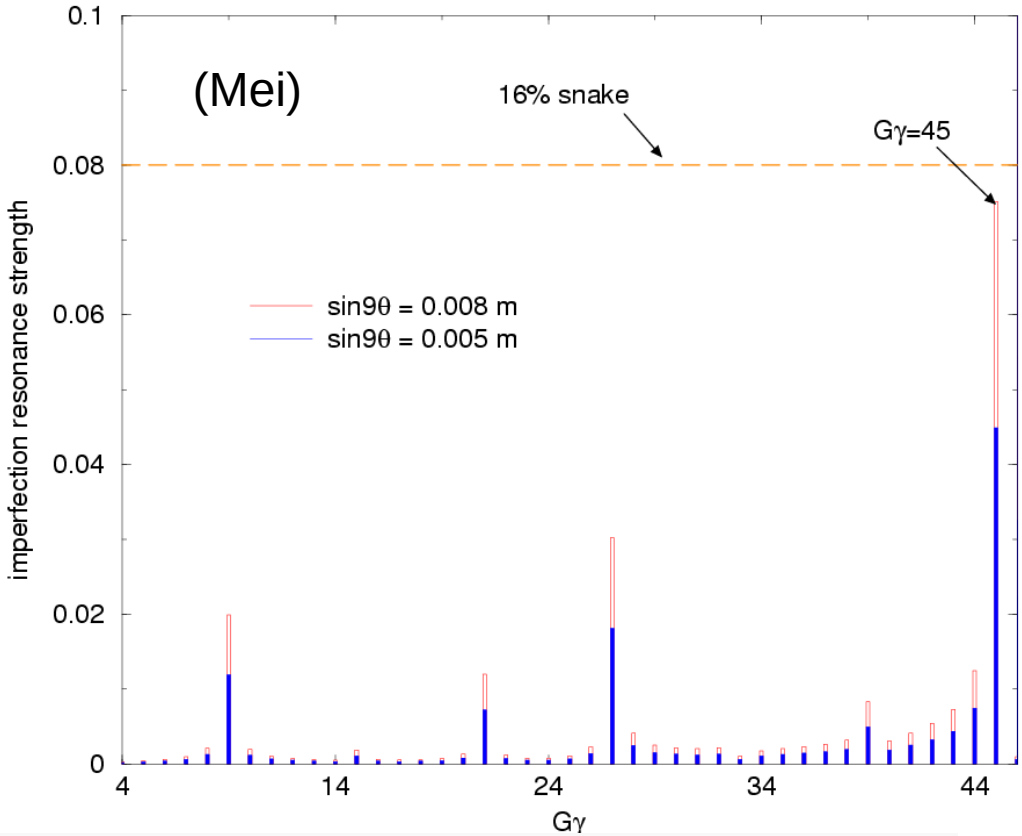
(Junpei)



Polarization as Function of Vertical Tunes

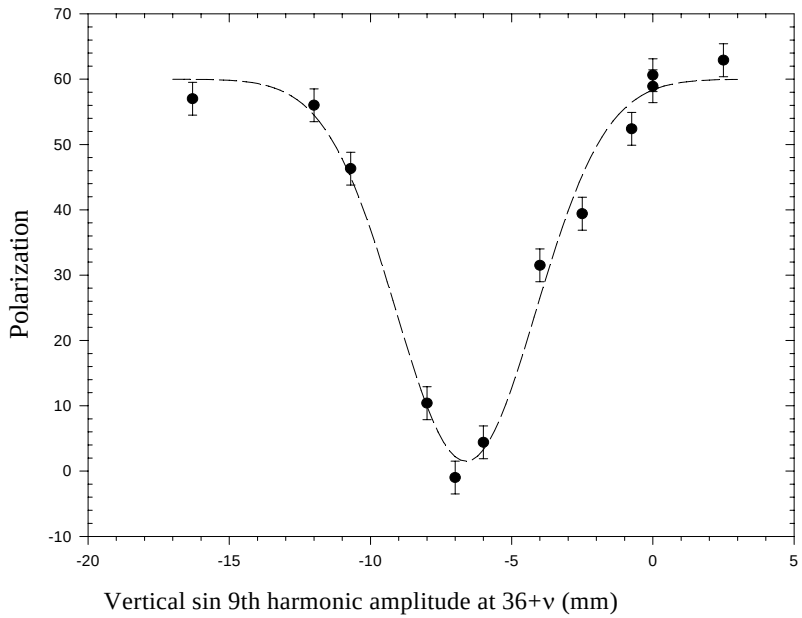


9th Harmonic at 36+ν



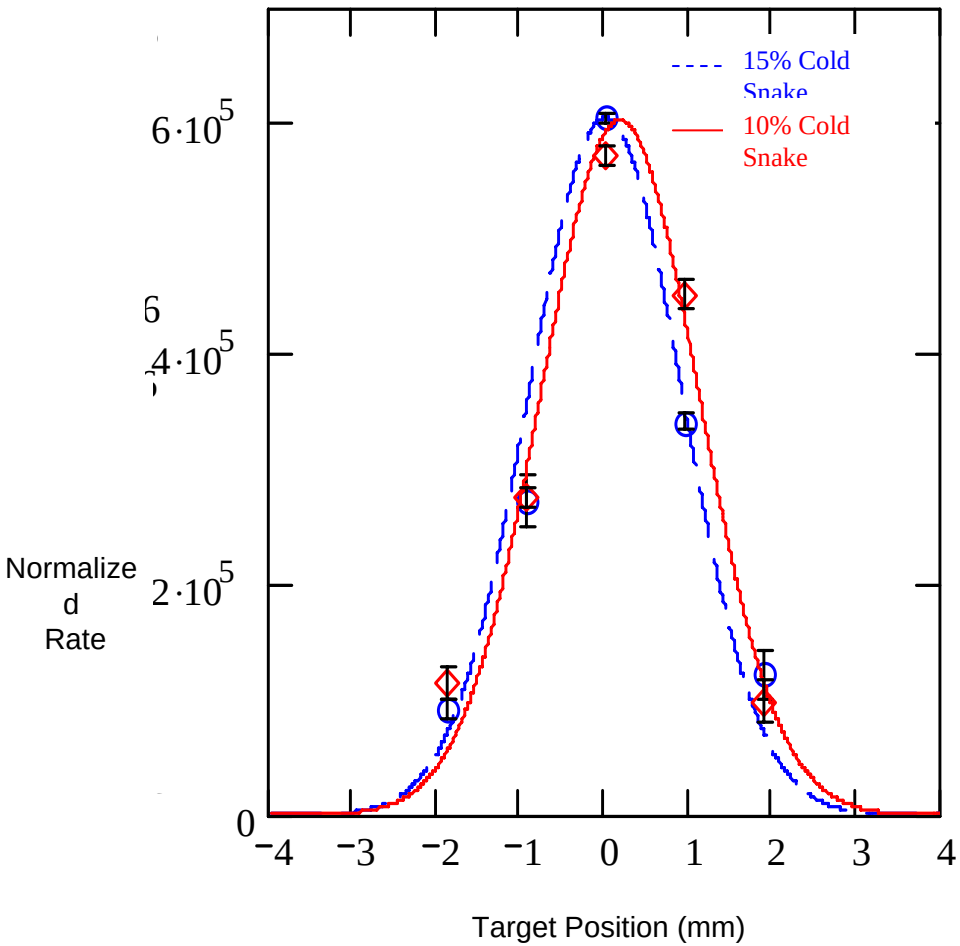
Measured polarization as function of the sine 9th harmonic amplitude at $36+\nu_y$. The dashed line is to guide the eyes. The location of the polarization dip agrees with model prediction.

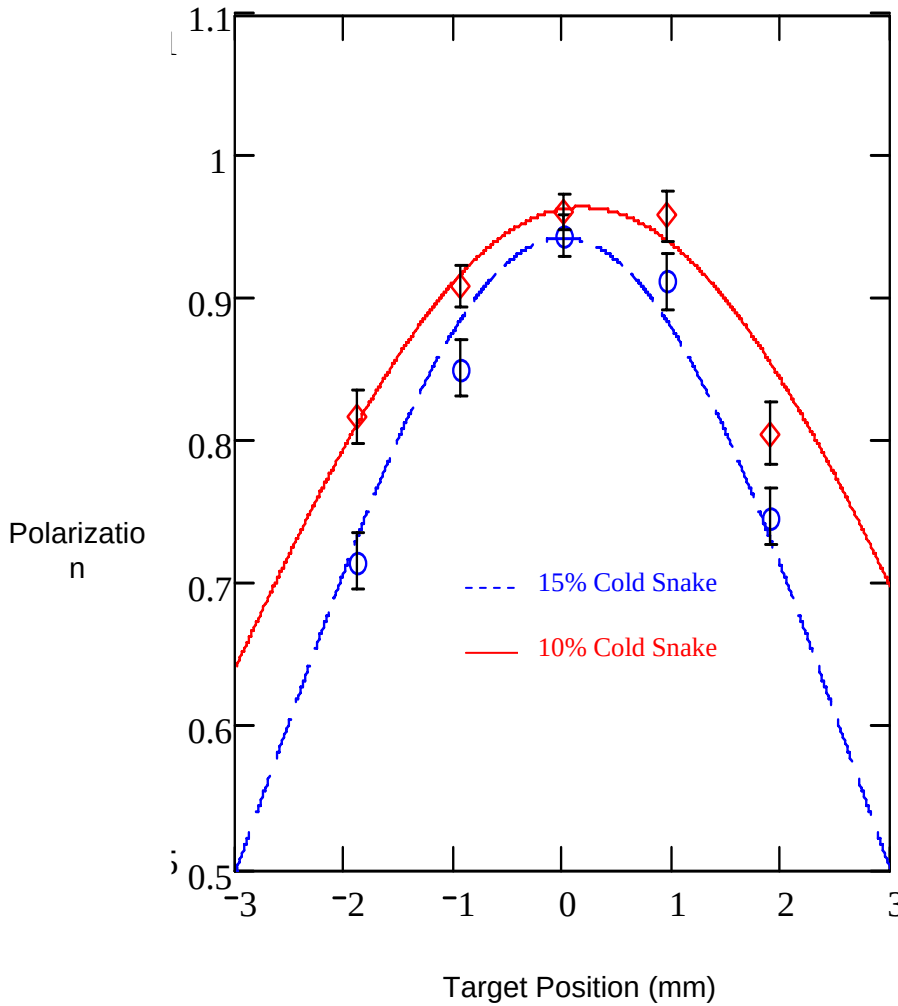
Estimated imperfection resonance strengths with large sin 9th harmonics. As can be seen, with 8mm sin 9th harmonic amplitude, the resonance strength is comparable to the 16% partial snake in the AGS. With certain phase between them, the effect of partial snakes is canceled by the large orbit distortion at Gγ=45 (near $36+\nu_y$).



Horizontal Polarization Profile

(Fanglei)





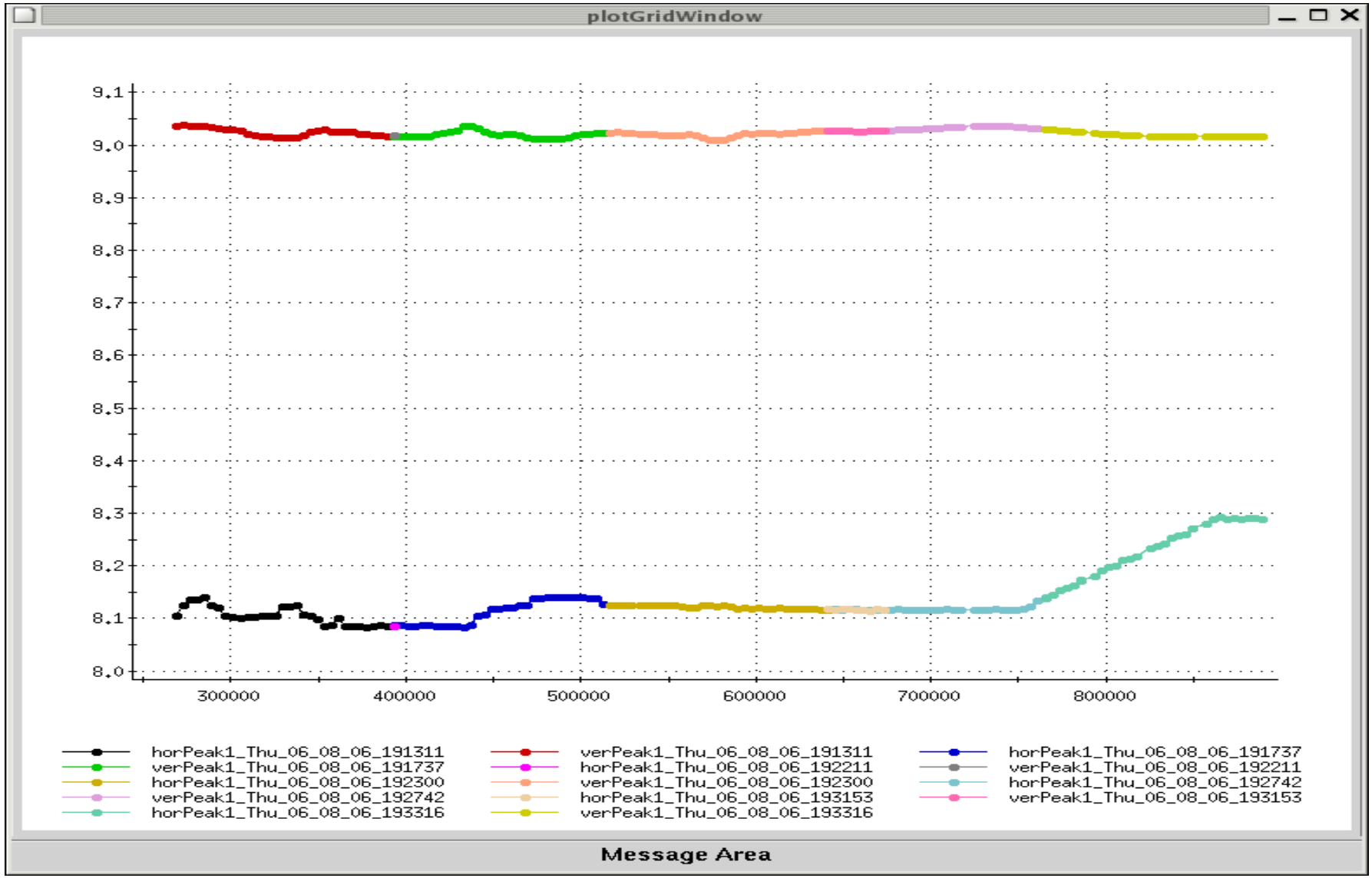
Injection on the Fly

- The idea is to maintain both horizontal and longitudinal emittances. The idea has been tested and it worked. Due to the limited time, the reduction of horizontal emittance has not been observed.
- The only constraint on this mode is that one can only injection one bunch into AGS.
- We will spend more time on this scheme next run.

Horizontal Tune Near Integer

- The idea is to put horizontal tune near 8 (~8.05) while maintain vertical tune close to 9 (~9.02). Both tunes are within the spin tune gap.
- With the fractional part of the two tunes are so close, the coupling has to be corrected very well.
- Since the horizontal resonance strength are very weak, the horizontal tune does not need to be so as close to integer as vertical tune.
- The idea has been tested and both tunes can be set to around 8.1 and 9.02. When quad current maximized at higher energies, the radius is moved to shift tune. Due to the limitation of power supply (650A in quads, unipolar sextupoles power supplies), we can only get horizontal tune to 8.1. But it proved that the idea works.

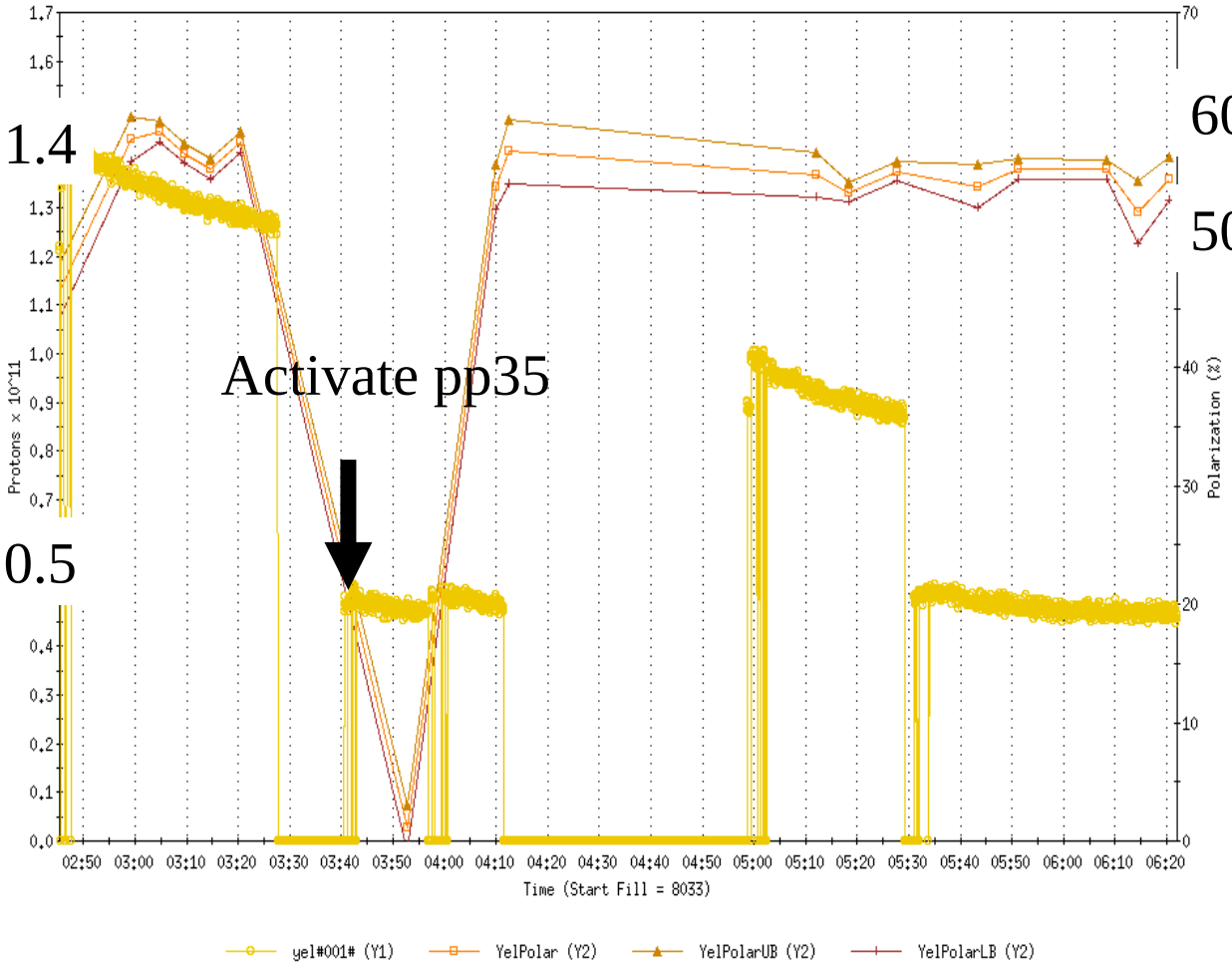
Horizontal Tune Near Integer (2)



Benign Intensity Dependence

- We seem to have emittance growth in the vertical dimension in the AGS as measured by the AGS IPM.
- The Booster scraping is mainly affecting the vertical emittance.
- With two partial snake solution, the vertical emittance is less a problem. That is the key to reach 65% polarization with higher intensity than the past.

Polarization vs. Intensity at Injection



YELLOW

1.4*10^11: 58.48+-0.39%;

1.0*10^11: 56.60+-0.80%;

0.5*10^11: 56.58+-0.52%.

AGS

$1.5*10^{11}$: 59.22+-2.44%

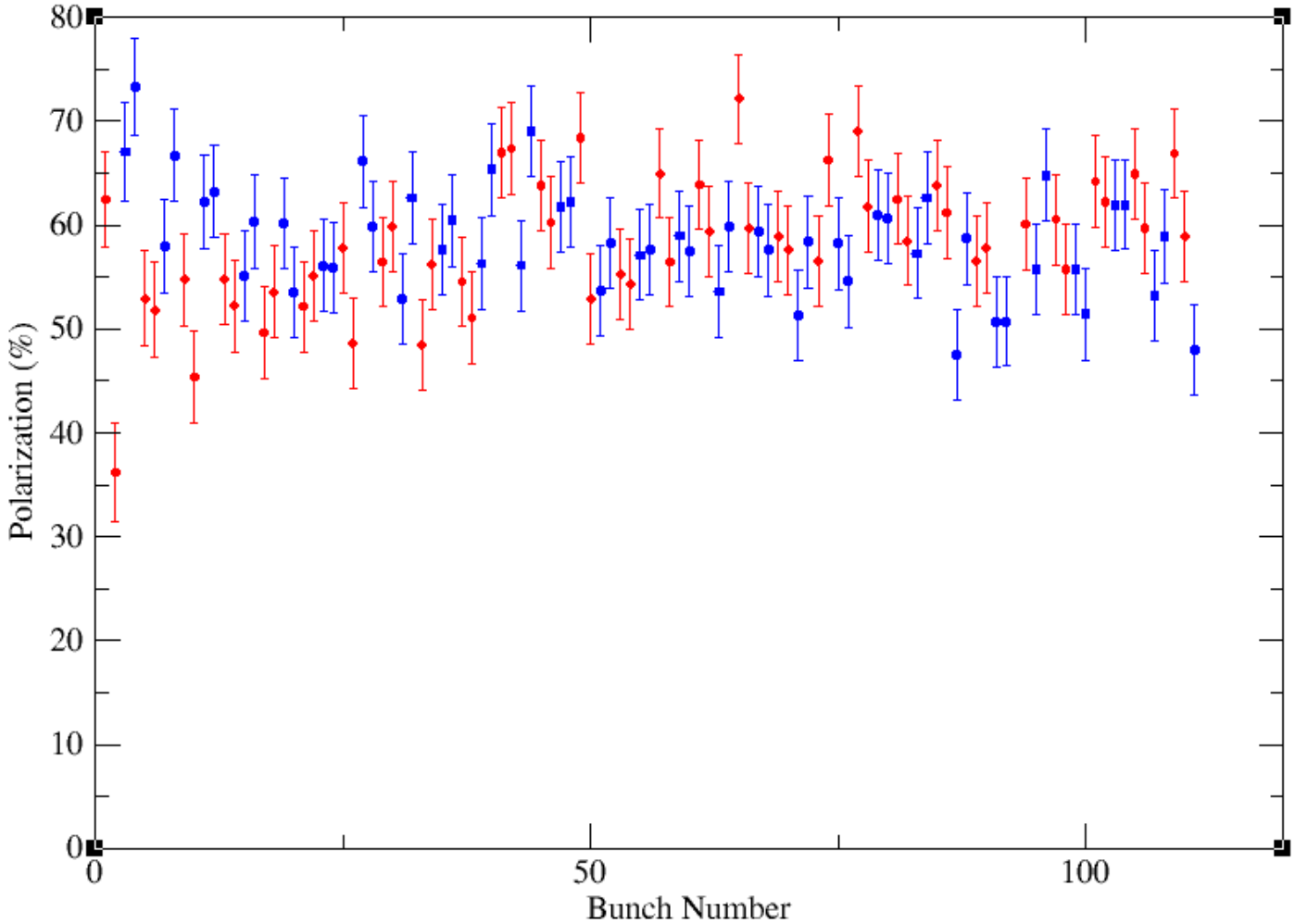
$1.1*10^{11}$: 60.98+-1.71%

$0.6*10^{11}$: 58.43+-1.71%

No intensity dependence in this intensity range.

This is very different from last year's operation with AC dipole.

AGS Stability



RHIC injection measurements with very long measuring time. Averaged over 420 million events. Error bar for each bunch is 4.7%. Trying to look for AGS variation from shot to shot. Need more statistics.

AGS Polarization Evolution

	2002	2003	2004	2005	2006
Intensity (10^{11})	0.7	0.7	0.7	1.0	1.5
Polarization	30%	40%	50%	50%	65%
	Slow ramp rate	Normal ramp rate	New warm snake	Booster Scraping	Cold snake

Source polarization and intensity gradually improved over this period.

Optically-pumped polarized H^- ion source (OPPIS) at RHIC.

RHIC OPPIS produces reliably 0.5-1.0mA (maximum 1.6 mA) polarized H^- ion current.
Pulse duration 400 us.
Polarization at 200 MeV
P = 82-86 %.

Beam intensity (ion/pulse) routine operation:

Source - 10^{12} H^-/pulse
Linac (200MeV) - $5 \cdot 10^{11}$
Booster - $2 \cdot 10^{11}$,
50% - scraping.
AGS - $1.7 \cdot 10^{11}$
RHIC - $1.4 \cdot 10^{11}$
(p/bunch).

A beam intensity greatly exceeds RHIC limit, which allowed strong beam collimation in the Booster, to reduce longitudinal and transverse beam emittances.

(Anatoli)

Software and Hardware Upgrade

- We have very good features of the new AGS tunemeter and improved IPM.
- The IPM will keep improving, to get more profiles in one AGS cycle.
- A series data has been taken to benchmark online model which is critical to understand the lattices with snakes inserted.
- AtR flags will be checked during the summer.
- Emittance measurement feature will be added to AGS CNI polarimeter.
- Narrower target (250μm->100μm) needs to be developed to get reliable measurement for intensity above 1.5*10^11.
- Some snake quad is not PPM. Noise reduction for snake quads?
- More requests for some AGS applications (harmonic correction, OrbitDisplay, etc)….

Highlights of the Run

- 65% polarization with 1.5×10^{11} intensity achieved with two partial snakes in the AGS.
- The following snake setup gave the best polarization: 10% cold snake, 5.9% warm snake.
- Added four compensation quads for warm snake worked very well. The lattice is easier to handle than last year without them.
- The intensity dependence is very benign with this setup.
- There is polarization loss of 5% due to each of vertical and horizontal resonances. The injection and extraction mismatch is about 1%. We expect 73% polarization with 82% input. There is still an relative 10% polarization loss unexplained.

Nature's imagination is much richer than ours.

Freeman Dyson